

STRANGENESS VIOLATING DIBARYON DECAY

Sheldon L. Glashow

Department of Physics, Boston University, Boston, MA 02215

Abstract

Non-standard physics may induce detectable flavor-changing $\Delta B = 2$ interactions without inducing their flavor-conserving counterparts. Searches for $n-\bar{n}$ oscillations do not constrain such interactions, thereby motivating dedicated searches for $\Delta B = 2$ nuclear decays into strange final states. In particular, the simple model herein proposed enables dibaryon decay exclusively into states with $S = 2$.

We begin with a brief parable. The flavor-conserving neutral currents of the electroweak theory were discovered in 1973, but could (and should) have been found a decade earlier. As Tini Veltman wrote,¹ “There was [in the 1960s] a rather heavy bias against [neutral current phenomena]. In quite different circumstances they had been found to be absent with a high degree of certainty... Experimentally, it had been made sure that even if there were such events they would not be discovered... There was not much interest in that question at that time, something that changed after 1971” when the electroweak theory was proven to be sensible. In other words, the failure to observe flavor-changing neutral currents in strange particle decays diverted experimenters from performing a timely search for flavor-conserving neutral currents in neutrino physics.

The situation regarding $\Delta B = 2$ processes appears to be inversely analogous. Novel interactions at a large mass scale could lead to two distinct observable phenomena: neutron-antineutron oscillations and dibaryon decays. Both processes have been searched for, but as yet neither has been seen.² Far more sensitive proposed searches for $n-\bar{n}$ oscillations³ may have dampened enthusiasm for further searches for dibaryon decay. However, one easily may build models that generate only strangeness-changing $\Delta B = 2$ operators. These do not generate strangeness-conserving $\Delta B = 2$ operators, nor do they yield $n-\bar{n}$ oscillations.[†]

[†] Has anyone looked for strangeness-changing dibaryon decays? The PDG offers constraints on 13 $\Delta B = 2$ decay modes, nary a one involving kaons.⁴

An example of such a model (by no means unique) serves as an existence proof. We introduce several massive spinless color triplets, each coupled to a pair of right-handed quarks. Color antisymmetry of these quark pairs demands that they also be flavor antisymmetric. The three relevant bosons, R_{ud} , R_{us} , and R_{ds} , possess the trilinear self coupling $\epsilon_{ijk}(R_{ud}^i R_{us}^j R_{ds}^k)$, which induces the effective $\Delta B = 2$ six-fermion interaction:

$$M^{-5} \epsilon^{ijk} (ud)_i (us)_j (ds)_k$$

where M is the relevant mass scale. This interaction mediates the $\Delta B = 2$ decay of a pair of nucleons, but exclusively into states with $S = 2$, *e.g.*, a pair of kaons. Note that flavor mixing of the quark masses cannot yield the flavor-conserving $\Delta B = 2$ term $uudddd$ and thus cannot induce $n-\bar{n}$ oscillations.

A one-loop diagram (with flavor mixing between R_{ud} and R_{us}) induces the $\Delta S = 2$ four-fermion interaction $M^{-2} s s \bar{d} \bar{d}$. For this operator to have a measurable effect on the neutral kaon system, M would have to lie below ~ 100 TeV, whence strangeness-changing dibaryon decay would proceed so rapidly that it could not have escaped detection. Conversely, dedicated searches for $\Delta S = 2$ dibaryon decay can be sensitive to values of M beyond 1000 TeV. Thus we see the need for experimenters at Super-K and elsewhere to pursue the search for dibaryon decays into strange final states, whether $S = 2$ as in our model, or $S = 1$ or 3 in other conceivable models. The discovery of such phenomena would open a window into new physics lying beyond the reach of the LHC.

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References

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- [3] *E.g.*, Y. Kamyshkov, `ArXiv:hep-ex/0211006`.
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